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(London) has been reduced in price, now costing American subscribers about $4.60. The pages have been reduced slightly in size, and some changes have been made in the type and heading. This valuable journal (to botanists as well as to horticulturists) now enters upon its third series.

ENTOMOLOGY.

Hauser on the Organs of Smell in Insects.[1]—Although Hauser's researches have been published in Germany several years, they were so carefully made and conclusive that our readers will, we feel sure, be glad to have laid before them in detail the facts which prove so satisfactorily that the antennæ of most insects are olfactory rather than auditory in their functions. Kraepelin in 1883 confirmed Hauser's views, and recently Will has published an excellent paper on the organs of taste in insects, especially wasps, etc., so that our knowledge of the senses of Arthropoda has been greatly extended and cleared up within the last few years. It now appears that few insects are known to have genuine ears, those of the locusts and grasshoppers being alone proved to be auditory organs. It appears that most insects (the sound-producing ones excepted) are probably deaf, while nearly all have very acute senses of smell, taste, and touch.

That many insects possess an unusually acute sense of smell no naturalist disputes. A point in debate, however, is the site of the organ of smell in these animals. The author attempts to settle the question.

I. *Physiological Experiments.*—First of all one should observe as exactly as possible the normal animal in its relation to certain smelling substances, whose fumes possess no corrosive power or peculiarities interfering with respiration; then remove the antennæ and try after several days to ascertain what changes have taken place in the relation of the animal to the substance. In order to come to no false results it is often necessary to let the animals operated upon rest one or two days, for immediately after the operation they are generally so restless that a careful experiment is impossible.

The extirpation of the antennæ is borne by different insects in different ways; many bear it very easily, and can live for months after the operation, while others die in the course of a few days after the loss of these appendages. The animals seem to be least injured if the operation is performed at a time when they are hibernating. *Pyrrhocoris apterus* L., and many other insects, afforded a very striking proof of this relation.

Experiments made by placing the antennæ in liquid paraffine so as to cover them with a layer of paraffine, thus excluding the air, gave the same result as if the antennæ had been removed.

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[1] Zeitschrift für Wissenschaft. Zoologie, xxxiv., 1880. Three plates.

The experiments may be divided, according to their object, into three groups. Experiments of the first kind were made on insects in their relation to strong-smelling substances, as turpentine, carbolic acid, etc., before and after extirpation of the antennæ. The second group embraces experiments on the relation of animals as regards their search for food; and finally the third group embraces experiments on the relation of the sexes relative to reproduction before and after the extirpation of the antennæ.

1. *Relation of insects to smelling substances before and after the loss of their antennæ.*—Taking a glass rod dipped in carbolic acid and holding it within 10 cm. of *Philonthus æneus*, found under stones at the end of February, it raised its head, turned it in different directions, and kept making lively movements with its antennæ. But scarcely had Hauser placed the rod close to it when it started back as if frightened, made a sudden turn, and rushed, extremely disturbed, in the opposite direction. When he removed the glass rod the creature busied itself for some time with its antennæ, while it drew them, with the aid of its fore limbs, through its mouth, although they had not come into direct contact with the carbolic acid. There was the same reaction against oil of turpentine, and it was still more violent against acetic acid.

After having many times carefully tested the relations of the normal animal to the substances mentioned, the antennæ were removed from the socket-cavity.

On the second day after Hauser experimented with the insects, they exhibited no reaction either against the carbolic acid, the oil of turpentine, or also against the acetic acid, although he held the glass rod which had been dipped into it for one or two minutes before and over the head. The creatures remained completely quiet and immovable, at the most slightly moving the palpi.

They showed otherwise no change in their mode of life and their demeanor; they ate with great eagerness flesh which had been placed before them, or dead insects, and some were as active as usual as late as May.

These beetles had, as proved by the experiments, lost the sense of smell alone; how far the sense of touch was lost Hauser could not experimentally decide.

The same results followed experiments with species of the genus Ptinus, Tenebrio, Ichneumon, Formica, Vespa, Tenthredo, Saturnia, Vanessa, and Smerinthus; also many species of Diptera and Orthoptera, besides Julus and Lithobius, while many larvæ reacted in the same manner.

Less satisfactory were the experiments with Carabus, Melolontha, and Silpha; there is no doubt that the species of these genera, through the extirpation of their antennæ, become more or less injured as to the acuteness of their powers of smelling; but they never show themselves wholly unable to perceive strong-smelling substances.

The allurement of the substance acts for a longer time on those deprived of their antennæ, then they become restless, then they wander away from the glass tube held before them; still all their movements are but slightly energetic, and the entire reaction is indeterminate and enfeebled.

Experiments with the Hemiptera gave still more unfavorable results; after the loss of their antennæ they reacted to smells as eagerly as those did which were uninjured.

2. *Experiments on the use of the antennæ in seeking for food.*—Under this head experiments were made with Silpha, Sarcophaga, Calliphora, and Cynomyia.

Silpha and its larva were treated in the following manner: they were placed in large boxes whose bottoms were covered with moss, etc.; in a corner of the box was placed a bottle with a small opening, in which was placed strong-smelling meat. So long as the beetles were in possession of their antennæ they invariably after a while discovered the meat exposed in the bottle, while after the loss of their antennæ they did not come in contact with it.

In a similar way acted the species of Sarcophaga, Calliphora, and Cynomyia. Hauser, in experimenting with these, placed a dish with a large piece of decayed flesh on his writing-table. In a short time specimens of the flies referred to entered through the open window of the room. The oftener he drove them away from the meat would they swarm thickly upon it. Then closing the window and catching all the flies, he deprived them of their antennæ and again set them free. They flew about the room, but none settled upon the flesh nor tried to approach it. Where a fly had alighted on a curtain or other object, the decayed flesh was placed under it so that the full force of the effluvium should pass over it, but even then no fly would settle upon it.

3. *Experiments testing the influence of the antennæ of the males in seeking the females.*—For this purpose Hauser chose those kinds in which the male antennæ differ in secondary sexual characters from those of the female, and in which it is known that they readily couple in confinement, as *Saturnia pavonia*, *Ocneria dispar*, and *Melolontha vulgaris*. The two first-named insects did not couple after the extirpation of their antennæ. Of *Melolontha vulgaris* twenty pairs were placed in a moderately-sized box. On the next morning twelve pairs of them were found coupling. Hauser then, after removing the first lot, placed a new set of thirty pairs in the same box, cut off all the antennæ of the males and those of a number of females. On the following morning only four pairs were found coupling, and at the end of three days five others were observed sexually united.

From these experiments Hauser inferred that those insects deprived of their antennæ were placed in the most favorable situation, such as they would not find in freedom; for the space in which the insects moved about was so limited that the males and females must of necessity meet. But at the same time the results of the experiments cannot absolutely be regarded as proving that the males, after the loss of their antennæ, were then not in condition to find the females, because in the case of the above-mentioned moths, under similar conditions, after the extirpation of the antennæ no sexual union took place. If, however, the experiments made do not all lead to the results desired, Hauser thinks that the results agree with those of his histological researches, that in the greater number of insects the sense of smell has its seat in the antennæ. His results also agree with those of Perris.

II. Histological Researches on the Organs of Smell in Insects.—The organs of smell consist, in insects,—*i.e.*, all Orthoptera, Pseudoneuroptera, Diptera, and Hymenoptera, also in most Lepidoptera, Neuroptera, and Coleoptera,—

1. Of a thick nerve arising from the brain which is sent into the antennæ.

2. Of a sensitive apparatus at the end, which consists of staff-like cells, which are modified hypodermis cells, with which the fibres of the nerves connect.

3. Of a supporting and accessory apparatus, consisting of pits, or peg- or tooth-like projections filled with a serous fluid, and which may be regarded as invaginations and outgrowths of the epidermis.

Hauser adds a remark on the distribution of the pits and teeth in the larvæ of insects, saying that his observations are incomplete, but that it appears that in the larvæ the teeth are most generally distributed, and that they occur not on the antennæ alone, but on the palpi; but in very many larvæ neither pits nor teeth[1] occurred. In the Myriopoda teeth-like projections occur on the ends of the antennæ. In Lithobius they form very small, almost cylindrical, pale organs.

In the course of a special description of these sense-organs in the Orthoptera, Hauser describes at length those of *Œdipoda cœrulescens* and *Caloptenus italicus*. On one antennal joint of Caloptenus was often counted fifty pits; on the anterior joints the number diminishes to about thirty. Hauser thinks that in all Orthoptera whose antennæ are like those of Caloptenus occur similar pits, as he found them in Stenobothrus as well as Œdipoda. Gryllotalpa possess similar pits,—four to six on each antennal joint, making between three and four hundred pits on each antenna.[2] In *Mantis religiosa* the pits were not detected,

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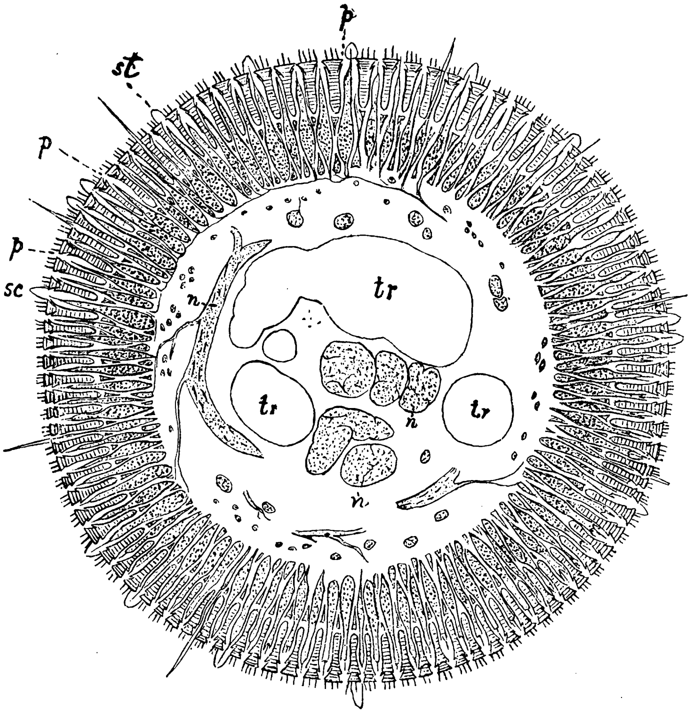
[1] Hauser here uses the word *taster*, but this means palpus or feeler. It is probably a *lapsus pennæ* for teeth (*Kegel*).

[2] In 1870 I observed these sense-pits in the antennæ, and also the antenna-like anal

PLATE XIV.

6.



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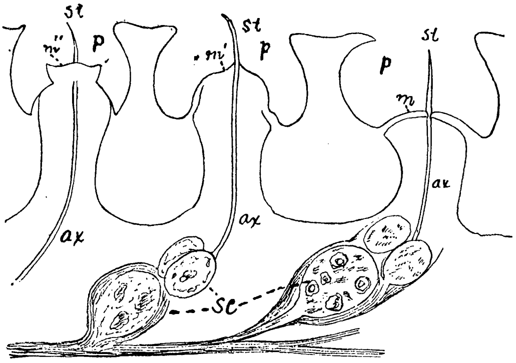

ORGANS OF SMELL IN INSECTS.

but on each joint, except the eight basal, there are about two hundred small, hollow-curved teeth with a fine opening in front.

In the Neuroptera (Chrysopa) there occur on the antennæ, besides numerous very long tactile bristles, small pale, transparent teeth. No pits could be detected.

In the Hemiptera (two species of Pyrrhocoris only were examined) only two kinds of tactile bristles occurred, but Hauser detected no pits, though Lespés states that they are present.

Of the Diptera, Hauser examined more than sixty species. The pits in the *Diptera brachycera* (Muscidæ, etc.) are unexceptionally confined to the third antennal joint. Their number varies extraordinarily in the different species. *Helophilus florens* has on each antennal disk only a single pit, while *Echinomyia grossa* possesses two hundred of them. In flies of certain families the pits are compound and contain ten, twenty, and often one hundred olfactory hairs, partly arising from the coalescence of several pits. Such pits are usually divided by lateral walls into several chambers, whose connection is only indicated by their common outlet. Simple olfactory pits with a single olfactory style were observed only in the Tabanidæ, Asilidæ, Bombylidæ, Leptidæ, Dolichopidæ, Stratiomydæ, and Tipulidæ. In the last the compound forms do not occur at all, but in the other families mentioned also occur compound pits, receiving from two to ten nerve-terminations.

The antennal pits of flies are always sac-like invaginations of the external chitinous integument, of manifold shapes, opening externally and never closed by a membrane. The pits differ but slightly in the different species, and that of *Cyrtoneura stabulans* (Fig. 2) is described at length as typical of those of brachycerous flies in general.

The olfactory pits of the Tipulidæ seem to have a somewhat different structure, since the external passage is closed. It is circular, surrounded with a slight chitinous wall and not covered with bristles. Such pits in their external appearance are like those of the locust (Caloptenus) and many Hymenoptera. They are situated usually on the third antennal joint. *Pachyrhina pratensis* L. has about sixty of them, as have *Tipula oleracea* L. and Ctenophora.

In the Lepidoptera, olfactory pits are much like those of flies. Hauser describes in detail those of *Vanessa io.* Those of the moths were not examined, but they can be readily and satisfactorily proved to be the site of the olfactory sense.

appendages (cercipoda) of the cockroach (*Periplaneta americana*). I counted about ninety pits on each stylet. They are much larger and much more numerous than similar pits in the antennæ of the same insect. I compared them to similar pits in the antennæ of the carrion-beetles, and argued that they were organs rather of smelling than hearing. (AMER. NAT., iv., Dec. 1870.) Organs of smell in the flies (Chrysopila) and in the palpi, both labial and maxillary, of Perla were described in the same journal.—*A. S. P.*

Historical researches in the Coleoptera generally gave a very unfavorable result, contrary to Lespés's views. That author states that in the Carabidæ the pits are found on the four first joints, but Hauser could discover them in none which he examined. Usually only tactile bristles occur, so also in the Cerambycidæ, Curculionidæ, Chrysomelidæ, and Cantharidæ.

Olfactory pits, however, without doubt occur in Silpha, Necrophorus, Staphylinus, Philonthus, and Tenebrio. The openings of the pits are small and surrounded with a small chitinous ring; in Silpha, Necrophorus, and Tenebrio they cannot easily be distinguished from the insertion-cavities of the bristles, but in Philonthus and Staphylinus they are less like them, being distinguished by their somewhat larger size and their often more oval form. In *Philonthus æneus* about one hundred such small pits occur irregularly on the terminal joints; besides, in this species on each side of the terminal joint is an apparatus, which is like the compound pit generally occurring in the Diptera.

Very remarkable pits occur in the antennal lamellæ of *Melolontha vulgaris* and other Lamellicorns. Only on the outer surface of the first and seventh (in the female the sixth) antennal leaf, as also on the edges of the other leaves, arise scattered bristles; on the inner surface of the first and seventh leaves, as also on both surfaces of the second to sixth leaves, are close rows of rather shallow depressions of irregular form, some circular, others regularly hexagonal. Their number is enormous: in the males thirty-nine thousand, in the females about thirty-five thousand, occur on each antenna.

The antennal pits and teeth of *Dytiscus marginalis* are morphologically and physiologically identical with those of bees and wasps. In *Anopthalmus bilimekii* St., Hauser found on the last antennal joints about sixty teeth, which essentially differ in form from those previously described; they are very pale, transparent, cylindrical, elongated, and bent elbow-shaped on the first third, so that the last two-thirds run parallel with the antenna. (Fig. 12.) The length of these remarkable teeth is 0.035 mm., their breadth 0.005 mm. I only found them in Anopthalmus, and in no other species of Carabidæ; they must resemble the teeth described in Chrysopa. Similar teeth occur on the maxillary and labial palpi of beetles. *Dytiscus marginalis* possesses at the end of each terminal palpal joint a group of very small teeth, which were also detected in *Anopthalmus bilimekii*, *Melolontha vulgaris*, etc. In *Carabus violascens* were detected on the maxillary palpi large, plainly microscopical, white disks which are surrounded with a great number of extremely small teeth.

Whether the above-described organs on the palpi of beetles should be considered as olfactory or gustatory in their nature can only be determined by means of physiological experiments; they probably receive taste-nerve terminations.

The Hymenoptera furnished very good material for histological purposes, so that Hauser could not only study the terminal apparatus of the olfactory nerves in the perfect insect, but also in three different stages of the pupa. These are described at length, as regards the distribution of the pits and teeth, in *Vespa crabro;* each joint of the antenna (flagellum) possesses between thirteen hundred and fourteen hundred pits, nearly sixty teeth, and about seventy tactile hairs; on the terminal joint there are more than two hundred teeth, so that each antenna has between thirteen thousand and fourteen thousand olfactory pits and about seven hundred teeth (Kegel). Fig. 6 represents a cross-section through the penultimate antennal joint of *Vespa crabro;* we can see how thick are the series of openings on the surface of the antennæ, and how regular is the distribution of the teeth.

The distribution of the olfactory pits and olfactory teeth is thus seen to be very general; the deviations are so insignificant that there is no reason for the establishment of more than one type.

Antennal pits with a small crevice-like opening occur in genera nearly allied to Vespa and also in most Ichneumonidæ, Braconidæ, and Cynipidæ. But the crevice-like openings in these families are considerably longer and often are of a somewhat twisted shape. In all the species with translucent antennæ we can recognize the inner mouth of the pit as a round or nearly round disk situated usually under the middle of the opening. The antennal pits of *Apis mellifica,* as well as those of Bombus and allied genera, differ from those of the Ichneumonidæ in being not like crevices, but circular openings.

The distribution of the olfactory peg or tooth-like projections (Kegel) seems to be much more limited than that of the pits in the Ichneumonidæ. Hauser could not find any. *Apis mellifica* possesses on each antennal joint only about twenty slender pale teeth, scarcely a third as many as in *Vespa crabro;* on the other hand Formica, of which genus several species were examined, seems to have far more teeth than pits; they are relatively long, pale, transparent and somewhat clavate; they are not unlike those of Chrysopa; on the terminal joint only were these round openings, which led into a bottle-shaped invagination of the integument and contained an olfactory style. In the Tenthredinidæ only teeth and no pits were to be detected. Sirex has on the under side of the nine last joints of each antenna a group of from two hundred to three hundred small teeth, which resemble those of *Vespa crabro;* Lyda has on the terminal joints about one hundred teeth.

The author then discusses these facts from the Darwinian point of view. His views we may present in a subsequent number of this magazine.—*A. S. Packard.*

EXPLANATION OF THE FIGURES.

LETTERING.—*a, a,* circular thickening of the skin surrounding the opening of the olfactory pit; *ax,* thread-like continuation of the nerve-cell; *b,* vesicle-like bottom of the olfactory pit, through which the olfactory style passes; *br,* bristle in Fig. 3, stout, and protecting the olfactory pit; *bs,* bent bristle or seta; *ch,* chitinous integument of the antennæ; *d,* seen in section; *f,* invaginated pit; *fv,* Forel's flask-shaped organ; *fvo,* its opening seen from the surface; *gl,* gland-like mass of cells; *hyc,* hypodermic cells; *i,* entrance into the canal belonging to the pit; *m,* olfactory membrane; *m', m'', mc,* membrane-forming cell; *n,* nerve of special sense; *nc,* nucleus of the sense- or ganglion-cell; *o,* opening into the olfactory pit; *p,* olfactory pit; *cp,* compound pits; *pw,* wall of the pit; *s,* a large seta; *sc,* sense- or ganglion-cell; *st,* olfactory or sense-style, sometimes peg-shaped; *tb,* tactile bristle.

FIG. 1. Olfactory organ of Caloptenus.

FIG. 2. Longitudinal section through the third antennal joint of a fly (*Cyrtoneura stabulans*), showing the compound pits from above and in section.

FIG. 3. Vertical section through a single olfactory pit in the antenna of the horse-fly (*Tabanus bovinus*).

FIG. 4. Antennal pit of *Melolontha vulgaris,* seen in vertical section.

FIG. 5. Section through an olfactory pit of *Vespa crabro.*

FIG. 6. Section through antennal joint of *Vespa crabro,* showing the great number of olfactory pits, the olfactory and tactile bristles.

FIG. 7. Olfactory pits of the antenna of *Melolontha vulgaris.*

FIG. 8. Olfactory pits of the antenna of Stenobothrus.

FIG. 9. Olfactory pits of the antenna of *Vespa vulgaris.*

FIG. 10. Olfactory pits of the antenna of Formica.

FIG. 11. Olfactory pits of the antenna of Bombus. FIGS. 7–11, after Kraepelin.

FIG. 12. Organ of smell of Anophthalmus. After Hauser.

ZOOLOGY.

Notes on the Larger Florida Planorbes.—Having occasion lately to examine a number of Planorbes from Florida, I noticed that considerable confusion exists in the names various collectors give the species. I give below notes on all the species I have received from the State.

Planorbis trivolvis Say.

P. bicarinatus Say. Northern Florida. Stearns has recorded this species from several Pacific coast localities. I found it abundant and typical in Southern Texas. It has, thus, a range nearly as extensive as the *P. trivolvis.*

P. tumidus Pfr. is not an uncommon species in the peninsula, though hitherto overlooked, probably confused with *glabratus* or *trivolvis.* This shell is quite distinct from all other Florida species. Several rather immature specimens, apparently the same, have been sent me from Wacama Lake, N. C.

P. glabratus Say. *P. duryi,* var. *intercalaris,* approaches this species in some characters. From the other known Planorbes, *glabratus* is quite distinct. Distribution probably the same as *P. tumidus,* but decidedly local, according to the information given by my correspondents.

P. duryi Wetherby is a form widely spread and apparently